

CONTENTS

1. THE CONCEPT OF FREQUENCY CONTENT	1
Trigonometric Sine and Cosine Functions	2
Generalized Sine and Cosine Functions	3
Degrees, Radians, and Grads	6
Derivatives of the Sine and Cosine Functions	6
Amplitude, Frequency, and Phase	9
Concept of Frequency Content	10
Complex Variable Tutorial	19
Complex Representation of Frequency Content	26
Summary	30
Bibliography	30
2. THE FOURIER SERIES	31
Fourier Series Frequency Content	32
Periodic Functions	34
Complex Form of Fourier Series	40
Properties of the Fourier Series	42
Fourier Series of Complex Functions	44
Additional Properties of the Fourier Series	45
Fourier Series of Odd and Even Functions	47
The Function $\sin 2\pi at$	51
Summary	54
Bibliography	54

3. THE FOURIER TRANSFORM	55
Fourier Transform Frequency Content	57
Properties of the Fourier Transform	62
The Gaussian Function	67
Convolution and Cross-Correlation	68
Symmetry Relations	75
The Impulse Function	75
Two-Dimensional Fourier Transforms	80
Properties in Two-Dimensions	81
Separable and Radial Symmetric Functions	82
Convolution in Two-Dimensions	85
Summary	86
Bibliography	87
4. THE DISCRETE FOURIER TRANSFORM	89
Nth Order Sequences	90
The Discrete Fourier Transform	91
Properties of the Discrete Fourier Transform	95
Symmetry Relations	99
Simultaneous Calculation of Real Transforms	100
The Fast Fourier Transform	102
Mixed Radix Fast Transforms	106
Summary	108
Bibliography	109
5. FOURIER ANALYSIS VIA A DIGITAL COMPUTER	111
Sampling a Function	112
The Sampling Theorem	115
Computer-Calculated Fourier Transforms	120
Computer-Generated Fourier Series	127
Sampling by Means of the Comb Function	131
Super-Gaussian Windows	134
Summary	147
Bibliography	147
6. SYSTEMS AND TRANSFER FUNCTIONS	149
Concept of a System	149
Impulse Response of a System	152

Transfer Function of a System	154
Impulse Response and Transfer Functions	156
Summary	157
Bibliography	157
7. VIBRATIONAL SYSTEMS	159
Transfer Function of the General Equation	159
Mechanical Systems	160
Electrical Systems	170
Transverse Vibration of an Infinite String	182
Transverse Vibration of a Finite String	188
Summary	193
Bibliography	194
8. OPTICS	195
The Fresnel Diffraction Equation	195
Fresnel Equation as a Fourier Transform	206
Thin Lenses and Diffraction	217
Imaging Properties of Lenses	223
Coherent and Incoherent Optical Systems	234
Resolution of Optical Systems	242
Spatial Filtering	248
Sampling Theory with Optics Applications	251
Summary	256
Bibliography	256
9. NUMERICAL ANALYSIS	257
Nonrecursive Algorithms	257
Nonrecursive Smoothing Algorithms	261
Derivative Algorithms	264
Recursive Algorithms	272
Finite Difference Calculus Review	275
Integration Algorithms	278
Interpolation Algorithms	286
Synthesis of Nonrecursive Filters	290
Summary	293
Bibliography	293

10. THE HEAT EQUATION	295
Derivation of the Heat Equation	295
Finite Sine and Cosine Transforms	297
One-Dimensional Heat Flow in Finite Bodies	299
Two-Dimensional Steady State Heat Flow	310
Two-Dimensional Transient Heat Flow	313
Heat Flow in an Infinite One-Dimensional Body	316
Summary	321
Bibliography	321
11. STOCHASTIC ANALYSIS	323
Review of Statistics	323
Review of Probability Theory	331
Review of Correlation Theory	340
Moments and the Central Limit Theorem	347
Convolution and Probability Distributions	352
Autocorrelation and Random Signals	355
Ensembles and Expected Values of a Random Signal	360
Systems and Random Signals	363
Stationary Signals and the Ergodicity Principle	366
Summary	368
Bibliography	368
Index	369